Chapter X

Prevention and Control of Communicable Diseases

THE PRACTICE OF MEDICINE includes not only the treatment of diseased individuals but also the prevention and control of disease and injury. Prevention always has been considered the most desirable way to attain good health. Aboard ship, maintenance of the highest possible levels of health should be the aim of all. Specific measures can be taken to prevent, control, or remove threats to health and efficiency. These measures include quarantine, immunization, proper sanitation, vector control, chemophylaxis (use of medication or other chemicals to prevent disease), and presentation of educational talks or audiovisual aids. Those in command of the vessel are responsible for provision or enforcement of these and other measures.

COMMUNICABLE DISEASES

Communicable diseases are those which can be transmitted from one host to another. Transmission may be direct or indirect to a well person from an infected person or animal; at times through an intermediate animal host, a vector; or the inanimate environment. Illnesses result when an infectious agent invades and multiplies in the host.

The occurrence and spread of disease are determined by an interplay of factors specific to the causative agent, the environment, and the individuals or groups to whom the disease occurs. Epidemics may endanger the operation and safety of the ship. If many fall ill, medical facilities, supplies, and personnel may be utilized so heavily that the sick will not receive adequate care. Thus, it is important to know how various diseases are spread and what measures should be taken to assure their prevention and control.

Environmental Sanitation

Environmental sanitation, which is very important in the control of communicable diseases, seeks to prevent the spread of pathogens by eliminating both sources and modes of transmitting the agents. Among examples are sanitary treatment, handling, distribution, and dispensing of water, milk, and food; treatment and disposal of sewage to avoid contamination of water and food supplies; air hygiene and sanitation to prevent airborne infection; and the control of vectors of disease agents. Due to programs of environmental sanitation, malaria and many of the enteric diseases, such as typhoid fever and cholera, have either been eradicated or significantly reduced in the United States and other countries.

Infectious Agents

Organisms that produce disease in man range in size from the submicroscopic viruses to the fish tapeworm, which may attain a length of over 30 feet. Microorganisms are found in both plants and animals, as single cell and many-celled types.

Several groups of infectious agents (and representative diseases which they cause) may be classified as follows:

Bacteria: (sore throat, pneumonia, tuberculosis, syphilis, bacillary dysentery, cholera).

Viruses: (common cold, influenza, poliomyelitis, smallpox, measles, and viral pneumonia).

Rickettsiae: (typhus fever and Rocky Mountain spotted fever).

Protozoa: (malaria, amebic dysentery, African sleeping sickness).

Metazoa: (filariasis, trichinosis, hookworm, and tapeworm diseases).

Fungi: (ringworm and athlete's foot).

Infectious agents usually are specific in their disease-producing capabilities. Several different organisms can produce diseases which resemble each other clinically (symptoms and course of the disease) and pathologically (anatomical changes caused by a disease). For example, the meningococci, tubercle bacilli, and the mumps virus can produce meningitis, which is an inflammation of the membrane that envelops the brain and spinal cord. However, a specific disease, such as tuberculosis, only can be caused by a specific agent—in this case the tubercle bacillus.

Disease Incidence (Occurrence)

After infection, the number of cases of a disease that will occur is determined by many factors, some of which are:

Number of infective organisms entering into the exposure; that is, whether the exposure was minimal or massive.

Virulence (disease-producing power) of the organism; that is, the degree of change it can produce in the host. *Pathogenicity* means the ability of the microorganism to produce disease. Some strains of a pathogenic species may be more virulent than others.

Susceptibility of the host, or its ability to resist infection. Immunities may be acquired through vaccination or by inheritance. In addition, the natural resistance of the body and a state of good health constitute strong defenses against infections. Infection by a disease-producing organism, therefore, does not result necessarily in clinically detectable disease. In the control of communicable disease, infected but apparently healthy people are as significant as those with all the symptoms and signs of the disease.

Chain of Infection

The chain of infection spreading through a host population has five links:

• A reservoir of infection or source of the agent.

• A portal of exit or mode of escape of the agent from the reservoir.

• A method of transmission of the agent from the source to the new host.

• A portal of entry into the new host.

• A susceptible new host.

Knowledge of the infection chain is required for the development of effective measures to prevent or control the spread, because the interruption or absence of any single link will prevent transmission of the disease. Thus, communicable diseases often are classified on the basis of their method of passing from the source to the host.

Sources of Infection

A reservoir of infection is the habitat of the infecting organisms, the sum of all sources of infection. Sources or reservoirs of infection may be human, animal, or environmental.

Most of the infectious diseases harmful to man have a *human source* or reservoir. Manifestations of the presence of the infective agent in the human reservoir range in degree from an asymptomatic (symptom-free) healthy carrier to frank (unmistakable) disease. The obvious cases of a disease vary downward in severity from fatal, through severe to moderate, to mild. The disease may be *atypical* or *abortive:* that is, the usual manifestations of the disease may not develop (atypical); or the patient may recover before all signs or symp-

toms occur (abortive). *Missed cases* are those which are not recognized either by the patient or the physician.

Carriers of infection may be transient or chronic. *Incubationary carriers* are those who harbor the infection during the incubation period prior to the onset of the disease. *Convalescent carriers* are those who continue to harbor the organism after recovering from the disease. Carriers of disease can be as important a source of infection as those who are ill with the disease. The relative importance of a carrier category differs with each specific disease. In meningococcal meningitis, for example, the number of asymptomatic (without symptoms) or transient carriers may far outnumber those who are ill with the disease. On the other hand, in measles the human is the source of infection only from the beginning of the catarrhal stage, until about five days after the rash appears. There are no asymptomatic carriers of measles as far as is known.

In general, *diseases of animals* (zoonoses) affect man only accidentally. In most cases, man is not a natural host for the infective agent. However, in certain diseases both man and another animal or animals are essential to the normal life cycle of the infecting agent. In these instances, the infective agents have differentiated stages in their life cycle that require two or more hosts for their development. Malarial mosquitoes, most tapeworms, the blood flukes of schistosomiasis, and the round worms causing filariasis are examples. In other instances, either man or another animal can serve as reservoirs of infection.

Animal species which can serve as reservoirs of infectious diseases that affect man include:

Gastropods
slugs, snails, mussels, oysters, clams;

Arthropods
(a) *insects* (lice, fleas, flies, bees),

(b) *arachnids* (spiders, mites, ticks),

(c) *crustaceans* (lobsters, shrimp, crabs, water fleas);

Fish; Birds; and such Mammals as
(rats, bats, cattle, horses, swine, dogs, cats, monkeys).

Some infectious agents live in the soil; thus the inanimate environment is the reservoir of infection in these illnesses. *Fungi* (such as those causing coccidioidomycosis, histoplasmosis, and blastomycosis) and *molds* are found in soil and dust or on vegetation grown in endemic areas (places where the disease is common). Certain species of bacteria which form spores also are found in the soil, but only if the soil has been contaminated previously with the spore. Tetanus (lockjaw) and anthrax are examples of diseases that may be acquired in this manner.

Portals of Exit

The ease with which an organism can escape from its infected host partly determines the ease with which it is transmitted to another host. Some agents never leave their hosts under ordinary circumstances. The larvae of the pork worm (*trichina*) that cause trichinosis, for instance, cannot escape from the tissues unless the host is eaten by another animal. In some diseases, the infecting organism cannot leave its host during certain stages of its development; for example, there is no spread of the *Treponema* that cause syphilis from a patient with the late stages of syphilis. From an epidemiologic (occurrence and distribution of a disease) standpoint, the important fraction of the reservoir of infection is that portion from which the agent *can* escape.

Usually there is only a single portal of exit for each species of infectious agent, but there can be more; for example, the respiratory tract and skin lesions in smallpox. Usually, the portal of exit is the same as the portal of entry. However, there are many exceptions to this rule.

Modes of Transmission

The spread of disease also depends upon the ability of the infecting organism to survive outside its reservoir (source). Transmission of the agent may be either direct or indirect.

Direct transmission methods include:

• *Direct contact* with the infected person, as in kissing or sexual intercourse.

• *Droplet spread,* in which an infected person, through sneezing, coughing, or talking, sprays the face of a noninfected person with droplets containing the disease-causing agent.

• *Fecal-oral spread,* in which fecal material from an infected person is transferred to the mouth of a noninfected person, usually by the hands. Usually the hands are contaminated by touching such things as soiled clothing, bedding, towels, and then touching the mouth where transmission occurs.

Indirect transmission of infectious organisms involves *vehicles* and *vectors* which carry disease agents from the source to the host.

Vehicles are inanimate or non-living means of transmission of infectious organisms. They include:

Water—If polluted specifically by contaminated sewage, it is the vehicle for such enteric (intestinal) diseases as typhoid fever, cholera, amebic and bacillary dysentery.

Milk—The vehicle for diseases of cattle transmissible to man, including bovine tuberculosis, undulant fever, and streptococcal infections from infected udders. Diseases in which milk serves as the link between man and man include typhoid fever, scarlet fever, and diphtheria. Milk also serves as a growth medium for some agents of bacterial diseases.

Food—It is the vehicle for typhoid and paratyphoid fevers, amebic dysentery, food infections, and poisoning. To serve as a vehicle, food must be moist, bland (not too acid or alkaline), raw or inadequately cooked, or improperly refrigerated after cooking, as well as having been in intimate contact with an infected source. Virtually any food meeting these requirements may be a vehicle for transmitting organisms that cause disease.

Air—It is the vehicle for the common cold, pneumonia, tuberculosis, influenza, whooping cough, measles, and chickenpox. Discharges from the mouth, nose, throat, or lungs take the form of droplets which remain suspended in the air from which they may be inhaled. When the moisture in these droplets evaporates, bacteria and viruses form "droplet nuclei" which remain for a long time to contaminate air, dust, and clothing. The nuclei thus suspended are sometime called aerosols. Although disease agents entering their hosts by way of the respiratory tract usually are airborne, direct contact by kissing, eating contaminated food, or using con-taminated drinking glasses also provide entrance through the gastrointestinal tract.

Soil—It can be the vehicle for tetanus, anthrax, hookworm, and some wound infections. In general, however, the soil does not carry human pathogens that are spread from one person to another.

Fomites—This term embraces all inanimate objects other than water, milk, food, air, or soil which might play a role in the transmission of disease. Fomites include bedding, clothing, books, even doorknobs and drinking fountains. In the past, great importance was placed on the role of fomites in transmitting disease. It was the reason for the emphasis on fumigation. Today it is generally believed that most pathogenic organisms do not live very long away from the host and are readily destroyed by drying and sunlight. Thus, the amount of disease spread by fomites is relatively small and does not warrant undue emphasis, especially if these precautions lead to the neglect of more important measures that will limit the spread of infection.

Vectors are animate or living vehicles which transmit infections in the following ways:

Mechanical transfer — Contaminated mouth-parts or feet of some insect vectors mechanically transfer the infectious organisms to the bite-wound or to food. For example, flies may transmit bacillary dysentery, typhoid fever, or other intestinal infections by walking over feces of the typhoid or dysentery host, and later leaving the disease-producing germs on food over which it walks.

Intestinal harborage—Certain insects harbor pathogenic (cause disease) organisms in their intestinal tracts. The organisms are passed in the feces or are regurgitated by the vector, and the bite wounds or food are contaminated. For example, in the transmission of the rickettsiae causing typhus fever, the organism is passed in the feces of the body louse and is rubbed into the bite-wound or other skin abrasion by the human host. In bubonic plague, the plague bacillus multiplies in the stomach of the flea, causing an obstruction. When the flea bites a rodent or man, the blood obtained is regurgitated into the wound and carries the plague bacilli with it.

Biologic transmission—This term refers to a vital change in the infectious agent during its stay in the body of the vector. The vector takes in the organism along with a blood meal but is not able to transmit infection until after a definite period, during which the pathogen changes. These biologic changes may be sexual reproduction, maturation, or multiplication; the time required for these biologic changes is referred to as the "extrinsic incubation period."

The parasite which causes malaria is an example of an organism which completes the sexual stages of its life cycle within its vector, the mosquito. The larvae of filarial worms undergo part of their development and mature in various flies and mosquitoes. The virus of yellow fever multiplies in the bodies of mosquitoes; and the microorganisms of the Rickettsiaceae family multiply in the bodies of mites, ticks, fleas, and lice. Such environmental factors as temperature and humidity may affect the vector and the extrinsic incubation period.

Portrals of Entry

The portal of entry is the anatomic route by which the infectious agent gains entrance into the body of the host. Often the portal of entry is the same as the portal of exit. Portals of entry and exit may be found in the following systems of the human body:

Respiratory system, including the nose, mouth, pharynx, larynx, trachea, bronchi, and lungs.

Gastrointestinal system, including the mouth, pharynx, esophagus, stomach, small and large intestines, rectum and anus, as well as the accessory organs of digestion that include the salivary glands, liver, gallbladder, and pancreas.

Skin, including special membranes such as mucous membranes, of which the conjunctiva is a type. However, unbroken skin is a barrier to infectious agents.

Genitourinary system, including the urethra, bladder, ureters, and kidneys in both sexes; the prostate, seminal vesicles, spermatic duct, epididymis, and testes in the male; and the vagina, uterus, fallopian tubes, and ovaries in the female.

In some cases the organ-system primarily involved in the disease process is also the portal of entry and exit of the causative organism. This is true, for example, of most of the respiratory and gastrointestinal diseases. On the other hand, the portal of entry frequently bears no relation to the organ-system involved in the disease. In rabies, for instance, the virus enters the host through a wound in the skin, produces a disease process in the central nervous system, and leaves the host through the saliva. Disease agents transmitted by arthropod vectors, for such diseases as malaria and yellow fever, enter and leave the host through the skin, but involve other tissues in the disease process.

Susceptible Host

A host is a living organism which harbors or nourishes another organism. This kind of relationship is called *symbiosis,* from a Greek word that means "living together." If the relationship is mutually beneficial to the two partners, it is called *mutualism.* In contrast, when one organism may injure, destroy, or live at the expense of the other, the relationship is called *parasitism.* Communicable diseases are manifestations of parasitism.

The occurrence of infection and disease, stated previously, is determined by a complex interplay of factors that pertain to the host and the infecting agent (parasite). In the host, these factors determine the host's *susceptibility* or resistance to infection. Susceptibility and *immunity* may be thought of as opposite ends of a scale, or range, with varying degrees in between of susceptibility or resistance. Both are relative expressions. Much depends upon the *virulence* (disease-producing power) of the infective agent and whether the dose is minimal or massive.

Immunity and Resistance

Immunity and resistance are the result of several processes, many of which are not yet fully understood, and no doubt there are other factors as yet unsuspected. Some factors are known to be inherent to living organisms, while others are known to be acquired. *Inherent host factors* which contribute to a human being's *resistance to infection* include:

Mechanical barriers, such as the skin and mucous membranes of the respiratory, gastrointestinal, and genitourinary tracts.

Body secretions which either destroy, trap, or wash away infecting organisms, such as tears, the urine, the digestive juices, perspiration, and the mucus of the respiratory tracts.

Certain cells of the blood (leukocytes), and cells of the reticuloendothelial system (macrophages) found in the liver, spleen, bone marrow, and lymph nodes. These remove infecting organisms and foreign particles from the body by engulfing and destroying them, in a process known as *phagocytosis.*

Acquired immunity is developed by the host after previous experiences with infecting organisms or their products. It is specific, that is, limited to those particular organisms. The immune process may be explained in this way:

When foreign protein is injected into the body, formation of an opposing substance is stimulated. The substance injected is called an *antigen* (*anti*body *gen*erator), and the opposing substance is called an *antibody* (bodies that are antagonistic). After entering the tissues, foreign substances such as bacteria and their toxins act as antigens and stimulate the tissues to form specific antibodies. Even though the immunity is specific for each antigen, a phenomenon of cross-immunity does exist. This is due to a similarity of reactive groups to different antigens. Thus, immune bodies formed in response to one disease frequently help protect against another. Antibodies react in many ways with the antigen which stimulated their production.

Antitoxins neutralize toxins (poisons) which are produced by snakes, insects, and plants as well as by bacteria. Some bacteria do not themselves enter the blood but pour their toxins into it, as in the case of tetanus, diphtheria, and botulism. Because such toxins are antigens that excite antibody formation, these antibodies are known as antitoxins. Because the toxin is prepared to act upon cells when it enters the blood, the progress of the disease is likely to be extremely rapid; death may occur before the body can make sufficient antitoxin

to combat the poison. This is true of the toxins (venoms) of certain snakes. Unless treated promptly with immune serum (antivenin), the snakebite victim may succumb within a few hours.

Acquired immunity may develop either *actively* or *passively.*

Active immunity results when the host is stimulated by an antigen to produce its own antibodies. This occurs naturally as a result of infection, or artificially after injection of antigens, which are known as vaccines and are developed in laboratories.

Passive immunity occurs when the host receives antibodies obtained from another human being, or from another animal which has been immunized actively against the antigen. Passive immunity occurs naturally in the newborn infant who receives antibodies from its mother through the placenta. In passive immunity, the injected foreign immune bodies usually circulate in the recipient's blood until they are destroyed by the reticuloendothelial system after three to five weeks.

Passive immunity is preferable to active immunity in treatment of acute illnesses, for it can be instituted within minutes. A good example of lifesaving passive immunity is that resulting from injection of antivenin for snakebite. Those who have been actively immunized, either naturally or through injection of vaccine, will produce antibodies more vigorously when exposed to the antigen of a particular disease than those lacking previous experience with the antigen. This is the so-called "booster" effect. The booster effect does not occur following passive immunization.

Other factors affect host resistance to infection and disease. These factors, which are imperfectly understood, are related to the environment, to conditions intrinsic to the host, and to the interactions of the two. Such environmental factors as temperature and humidity seem to influence the host's receptivity and reactions to infection.

Ionizing radiation, such as X-rays and gamma rays from nuclear reactions, is known to depress host resistance to infection. The physiologic status of the host—as determined by nutrition, fatigue, age, or the presence of

pathologic conditions—is significant in the development of infectious diseases. Resistance may be sex-linked. Communicable disease death rates are generally higher in males than females, with the exception of whooping cough. Some authorities believe that race also influences resistance or susceptibility to communicable diseases, but this has not been established conclusively.

CONTROL OF COMMUNICABLE DISEASES

Measures for the prevention or control of communicable diseases are intended to break the chain of infection at its weakest link. In general, control measures attempt to prevent exposure to infection. These measures are strengthened by increasing the resistance of the susceptible host. This can be achieved by active or passive immunization or by the prophylactic use of drugs.

Reservoir Eradication

Exposure to infection can be prevented by eradicating the reservoir of infection, closing the portals of exit from the sources, and eliminating the modes of transmission. For example, in the United States, human tuberculosis caused by the bovine (infecting cattle) strain of the tubercle bacillus has been virtually eradicated by searching for and destroying infected cattle. Outbreaks of bubonic plague long have been controlled—that is, prevented from reaching epidemic proportions—by destroying rats and other rodents.

Isolation

Isolation of the infected persons and quarantine of susceptible contacts are among the oldest public health procedures. They have many shortcomings if attendants neglect other sources such as missed cases, atypical cases, and healthy carriers of infection.

Immunization

Every seagoing person, if only for self-protection and convenience, should be immunized against smallpox, diphtheria, tetanus, and poliomyelitis. In some ports, shore liberty should be contingent upon valid evidence of recent successful immunizations. "Booster" im-

munizations for smallpox *every three years* and diphtheria-tetanus *every ten years* should be kept current.

Protection against smallpox by vaccination has been observed for many years. Although it is no longer required in most areas of the United States, vaccination will be essential for international travel as long as smallpox continues to exist anywhere in the world. Protection against tetanus (lockjaw) by injection of a toxoid is recommended universally as part of good preventive medical practice. Regular "booster" immunization at *10-year intervals* is advisable for everyone regardless of occupation. Tetanus exposure is especially high on ships carrying cattle, hides, or similar cargoes and is common on land throughout the world.

A second category of special immunizations is the use of vaccines for yellow fever, cholera, and typhoid fever, depending on the route and destination of the vessel. Yellow fever vaccine is required at *ten-year intervals* for disembarkation in many tropical American and African countries. Cholera vaccine may be required at *six-month* intervals for travel to certain parts of the world. Avoiding food and water, which may be contaminated, is the most effective means of protection against typhoid fever and cholera. Typhoid vaccine may be a helpful adjunct when traveling in countries where typhoid commonly occurs, and food and water control cannot be effected.

A third category of protective agents includes those considered elective for special situations. For instance, plague vaccine might be considered for seamen anticipating frequent or prolonged travel in Southeast Asia, currently one of the few areas reporting much plague. *Immune serum globulin (ISG)* protection against hepatitis might be considered for those traveling in hepatitis-endemic areas of the world. Booster doses of ISG *every six months* might be useful for *perhaps three or four years,* if prolonged exposure cannot be avoided.

Malaria prophylaxis, with weekly doses of 500 mg of chloroquine phosphate (equivalent to 300 mg of chloroquine) is a necessity for all seamen working or stopping over in most tropical areas of the world. Routine immunization against typhus is not indicated today, as louse control remains the most effective method of control.

Seamen may require immunization to reduce the incidence of hepatitis B virus.

Seaman's Immunization Record

Every seaman should have immediately at hand, written evidence of the immunizations and prophylaxis that he has received. Having these records immediately available is more than a convenience for going ashore. It will prevent repeated and unnecessary immunizations when signing-on, or entering an infected port, or a port that requires immunization documents.

Over-immunization usually can be recognized by a severe local reaction following a routine booster, as for example, diphtheria-tetanus toxoid. *This should be noted in the seaman's record.* Generally no specific treatment for such a reaction is required.

Although some immunizations can be completed by a single procedure that will require only a few minutes, others require two or three doses over a two to eight week period. This can present a problem to merchant seamen. It is recommended that they arrange for multi-dose immunizations during layovers ashore, if no staff officer in the crew is qualified to administer them. (See p. App. B–9+.) Seamen should contact the Public Health Service hospital or outpatient clinic to receive the appropriate immunizations. These facilities also have the current regulations concerning the immunizations required for various parts of the world.